

1 **METHOD OF MONITORING A FILTER SYSTEM FOR A PAINT SPRAY**
2 **BOOTH**

4 **BACKGROUND OF THE INVENTION**

6 Field of the Invention

8 (001) The invention relates to the field of paint spray booths and, in particular,
9 to a filter monitoring system for the spray booth that insures that the maximum
10 available filter life is obtained.

12 Description of Related Art

14 (002) Environmental regulatory agencies requires self-disclosure of violations
15 to the appropriate Government Agency. Heavy fines are applied to companies
16 that fail to meet the clean air standards. Under this law, paint spray booths
17 equipped with filter systems are closely monitored to prevent over spray from
18 reaching the atmosphere. In addition, the operator within the booth must be
19 protected. Thus spray booth monitoring systems are available that provide
20 alarm signals when the filter(s) is near the end of its useful life.

22 (002) For example, in US Patent No.: 5,356,334 "Apparatus And Method For
23 Airborne Particulate Booth" by R. D. Gray uses sensors to monitor the
24 pressure drop across filters. A signal is provided when the filters are near the
25 end of their useful life. The apparatus is primarily designed for use in powder
26 type spray operations. Therefore, it uses a filter pulsing system to periodically
27 unclog the filter(s). When the pulse rate becomes almost constant, the alarm
28 signal is activated. The system also provides for signaling when the end of
29 filter life is approaching and shutting down the system should the filter become
30 clogged to a point that it is ineffective. However, it is not desirable to

1 completely shut down the spray booth. There may be a considerable amount
2 of particulate matter still in the spray booth.

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4 (003) Another example can be found in US Patent No. 5,554,416 "Automated
5 Air Filtration And Drying System For Waterborne Paint And Industrial
6 Coatings" by F. G. Scheufler, et al. Pressure sensors upstream and
7 downstream of the main filter are used to monitor pressure drop across the
8 filter. As the pressure drop increases, signaling filter loading, a signal is sent
9 to a blower to increase the flow rate to compensate therefore. A series of
10 lights illuminate as the blower speed increases indicating filter condition. Thus
11 adequate warning is provided to the operator to turn off the spray booth prior
12 to complete filter failure. However, such a system depends upon the alertness
13 of the operator to shut down the spray booth. Thus there is always a
14 possibility that of operator error. In addition, the Scheufler, et al. system does
15 not compensate for initial filter condition

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17 (004) Another example can be found in Published Patent Application No.: US
18 2002/0062788 AI "Apparatus And Method For Configuring Spray Coating
19 Application Systems" by D. M. Czech, et al. Here a system to remotely
20 monitor the performance of a spray-coating booth via the Internet and the like,
21 however, no specific mention of filter monitoring is made.

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23 (005) US Patent No.: 6,168,646 "Flow Rate Control Of Temperature
24 Controlled Fluids" by W. L. Craig, et al. discloses the use a filter assembly
25 including a first roller of fresh filter material and a take up roller. The filter is
26 disposed across the airflow path. As the exposed portion of the filter becomes
27 clogged, the pressure drop there across causes the exposed portion of the
28 filter to distort. This causes the exposed portion of the filter to make contact
29 with a switch, which activates the rollers causing the take up roller to pull
30 unexposed filter material off the first roller across the flow path and winding up

1 the clogged portion on the take up roller. However, no warning device is
2 provided for indicating that the last portion of the filter is clogged.

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4 (006) US Patent No.: 6,040,777 "Device And Process For Indicating The
5 Exhaustion Of A Fan Filter" by K. Ammann, et al. also discloses a device for
6 determining filter life. However, the filter is designed to remove gases from the
7 air. A gas detection device measures the level of the gas and if it rises to a
8 predetermined level, indicating filter saturation, an alarm signal is provided.

9
10 (007) Thus it is well-established practice to monitor filter performance in a
11 paint spray booth and the like. However, none of the prior art discloses a
12 system that takes into account the initial pressure drop across a new filter may
13 vary from filter to filter. For example consider a filter where the end of useful
14 life occurs when the pressure drop increase across the filter is 3 PSI. If the
15 initial pressure drop reading is 0.5 PSI, then a significant portion of the filter life
16 is lost. Furthermore, none of the prior art devices constantly monitors the
17 pressure drop across the filter, so that any unusual increases or decreases
18 that indicate a problem in the spray booth can be investigated. None of the
19 prior art devices address the problem of particulate matter that maybe still in
20 the air after the spray booth has been shut down. .

21
22 (008) Thus, it is a primary object of the invention to provide a filter monitoring
23 system for a spray painting booth.

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25 (009) It is another primary object of the invention to provide a filter monitoring
26 system for a spray painting booth incorporating a system to indicated filter
27 status.

1 (010) It is a further object of the invention to provide a filter monitoring system
2 for a spray-painting booth that provides automatic shut off of the operation of
3 the spray gun at a predetermined percentage of the filter life.

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5 (011) It is a still further object of the invention to provide a filter monitoring
6 system for a spray painting booth that takes into account the initial pressure
7 drop across the filter prior to establishing the expected life of the filter.

8
9 (012) It is another object of the invention to provide a filter monitoring system
10 for a spray painting booth that provides a warning if there is a discrepancy
11 between the reading at the end of one paint spraying shift and the beginning
12 of another.

13 14 **SUMMARY OF THE INVENTION**

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16 (013) A typical paint spray booth comprises a closed off room having a bank
17 of primary filters at one end. A blower assembly is in communication with the
18 filters and draws air from the room through the primary filters. The output from
19 the blower is coupled to one or more secondary filters. Thus with an operator
20 spraying parts within the room by means of an air powered type spray gun,
21 excess paint particles are collected on to the primary filters and vapors and
22 smaller particles are collected on the secondary filters.

23
24 (014) The invention is a method of monitoring a filter (either the primary or
25 secondary filters or both) for absorbing paint particles or vapors produced
26 during spray painting with a spray gun in a paint spray booth coupled to an
27 exhaust pump. The method comprising the steps of:

- 28 1. Installing a filter between the booth and exhaust pump.
29 2. Determining the initial pressure drop across a filter prior to use of the spray
30 booth. This is accomplished with the use on pressure sensors on either side
31 of the filters.

1 3. Determining the maximum allowable pressure drop for the filter prior to the
2 requirement that spraying activities must be terminated by adding the initial
3 pressure drop of the filter to the maximum allowable increase in pressure drop
4 across the filter before the spraying activities must be terminated.

5 4. Providing a warning when a first portion of the maximum allowable pressure
6 drop is reached; and

7 5. Preventing the use of the spray gun, while keeping the blower in operation
8 when a second portion, greater than the first portion, of the maximum
9 allowable pressure drop is reached.

10
11 (015) Preferably, the spray gun is pneumatically (air) powered by pressurized
12 air via a line. A solenoid valve is mounted therein for controlling the airflow
13 there through coupled to the spray gun. Thus the step of preventing the use of
14 the spray gun, while keeping the blower in operation, when a second portion,
15 greater than the first portion, of the maximum allowable pressure drop is
16 reached, includes the step of actuating the solenoid valve to the closed
17 position cutting off airflow to the spray gun.

18
19 (016) The first portion of the filter life is about 80 percent of the maximum
20 allowable pressure drop, but can be adjusted depending on operation's
21 requirements. The second portion is 90 percent of the allowable pressure
22 drop, but can adjusted depending on the operation's requirements. It is
23 preferred that the pressure transducers be connected to a computer with a
24 display terminal. Thus the method further includes the step of monitoring the
25 pressure drop across the filter on the display terminal. In addition, method
26 also includes the step of sending an alarm signal to the computer and
27 displaying the alarm signal on the display terminal.

28
29 (017) The novel features which are believed to be characteristic of the
30 invention, both as to its organization and method of operation, together with
31 further objects and advantages thereof, will be better understood from the

1 following description in connection with the accompanying drawings in which
2 the presently preferred embodiment of the invention is illustrated by way of
3 example. It is to be expressly understood, however, that the drawings are for
4 purposes of illustration and description only and are not intended as a
5 definition of the limits of the invention.

6 7 **BRIEF DESCRIPTION OF THE DRAWINGS**

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9 (018) Figure 1 is a top view of a typical paint spray booth

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11 (019) Figure 2 is a side view of the paint spray booth illustrated in Figure 1

12
13 (020) Figure 3 front view of a panel attached to an outer wall of the spray
14 booth shown in Figure 2 taken along the arrow 3.

15
16 (021) Figure 4 is a flow chart of the computer program for monitoring spray
17 booth filters.

18
19 (022) Figure 5 is a typical computer screen for monitoring filter performance.

20
21 (023) Figure 6 is a typical computer screen for changing a filter.

22
23 (024) Figure 7 is a flow chart of the portion of the computer program for
24 calculating the useful life of the filter.

25 26 **DESCRIPTION OF THE PREFERRED EMBODIMENT**

27
28 (025) Referring to Figures 1 and 2, the spray booth, generally indicated by
29 numeral 10, includes an air powered spray gun 12 coupled to a line 14, which
30 in turn is connected to a paint spraying apparatus 16. The apparatus 16
31 includes a normally closed valve 20 that controls the flow of air to the spray

1 gun 12. It should be noted that, while a pneumatically powered spray gun is
2 illustrated, any spraying system could be used in the booth 10. Mounted at
3 end 22 of the booth 10 is a bank of primary filters 24, having first sides 25A
4 and second sides 25B, designed to absorb particulate matter. The filters 24
5 divide the booth into a spraying area 26A and small chamber 26B. A blower
6 28 having an inlet duct 30 connected to the chamber 26B and an exhaust
7 duct 32 coupled to a secondary filter 34. The secondary filter is a High
8 Efficiency Particulate Air Filter (HEPA) that insures that small particulate
9 matter is removed from the air prior to reaching the ambient. Thus during
10 paint spraying operations the blower 28 draws the particulate matter through
11 primary filters 24 and pumps the remaining small particulate matter laden air
12 through the secondary filter 34. Such paint spray booths are in wide use
13 throughout most industries. It is critical that a filter monitoring system be
14 incorporated in order to meet Government mandated personnel safety and air
15 quality requirements. The failure to do so can and will result in large fines and
16 or criminal prosecution.

17
18 (026) The filter monitoring system includes a manometer device 39 having
19 pick up ports 40 and 42 positioned on each side 25A and 25B of the filter 24
20 and a second manometer device 43 having pickup ports 44 and 46 on each
21 side of the filter 34. The manometers 39 and 43, as well as valve 20 are
22 connected to a remotely located computer assembly 48 having a computer 49
23 display terminal 50 and keyboard 52. Referring to Figure 3, the manometer 40
24 includes a panel 56 having digital gage 57A and analog gage 57B. The panel
25 56 further includes a switch 58 for manually controlling valve 20. In addition, a
26 keypad 60 is provided to prevent unauthorized use. Thus should the computer
27 system, to be subsequently discussed, fail, the valve 20 can be manually
28 controlled. The blower 28-control panel (including on/off switch) is indicated by
29 numeral 59.

30

(027) Figure 4 is a Process Flow Chart for the computer program to monitor filter performance. It comprises the following steps:

(028) Step 60 Log in or out- The operator swipes their identification card or manually enters the data. When the operator logs on, the screen as depicted in Figure 5 appears on the terminal screen. The screen includes the following displays:

Logged On and Off Indicator Light 60

Spray gun Air Condition Light (valve 20 open or closed) 62

Operator Name Window 64

Acknowledge Alarms Button 66 (Touch Screen Indicator)

Details and New Filter 68 (transfers to Figure 6 screen) which will be subsequently discussed. Also a touch screen indicator.

Primary Filter Digital Read Out 70

Primary Filter Gauge 71

Secondary Filter Digital Read Out 72

Secondary Filter Gauge 73

Message Screen 74

Screen Setting Button 76

Log IN/OUT Button 77

Exit Program Button 78

(029) Step 79 Determination Of Pressure Drops. If there is no pressure drop, the blower 28 is not running. Then the system automatically goes back to step 60. If pressure drops are sensed, then to Step 80.

(030) Step 80 Enter Data- Time, Operator name and ID are recorded as well as an initial pressure drop reading across filters 24 and 34.

(031) Step 81 Determination If Operator Logging On Or Off- The existing pressure drop across the primary and secondary filters, is determined and

1 recorded. If there is no pressure drop, then to step 83. If there is a pressure
2 drop, then to Step 84.
3
4 (032) Step 83 Shut Off Valve 20- If Valve 20 is open, a signal is sent to the
5 valve causing it to shut down cutting off air pressure to spray gun 12.
6
7 (033) Step 84 Activate Solenoid Valve 20- A signal is sent to the valve 20
8 causing it to open and allow operation of the spray gun 12.
9
10 (034) Step 86 Monitor Pressure Drops- The program continues to monitor the
11 pressure drops across the primary and secondary filters, 24 and 34. These
12 pressure drops are indicated on the Screen in Figure 4.
13
14 (035) Step 88 Check Accuracy- The pressure drop determination across the
15 primary and secondary filters 24 and 34 is compared to last reading made. If
16 there is a significant change, a warning is provided in the message screen 74
17 in Figure 5. If no error is detected, then to Step 96. For example, one of the
18 filters could have had a structural failure or have blown out. This would result
19 in a significant change in pressure drop readings.
20
21 (036) Step 90 Display Alarm- An error signal is generated causing a "ALARM
22 CONDITION" message to appear at the message screen 78 (Figure 4).
23
24 (037) Step 92 Send E-mail- Email notifications are sent to all effected
25 departments.
26
27 (038) Step 94 Record Information- Automatically back to Step 83 Shut off
28 Valve 20. As previously stated, that if there is not significant change recorded
29 in the Step 88 Check Accuracy, Step 96 follows.
30 (039) Step 96 Determine 90 Percent Point Of Primary Filter- The actual
31 pressure drop across the primary filter 24 is compared to the point where the

1 filter is completely filled and if the 90 percent point is reached then to Step 90.
2 If not, to step 98. Note that the level at which the can be adjusted upward or
3 downward.
4
5 (040) Step 98 Determine 80 Percent Point Of Primary Filter- The actual
6 pressure drop across the primary filter 24 is compared to the point where the
7 filter is completely filled and if the 80 percent point is reached then to Step
8 106, which will be subsequently discussed. The 80 percent warning can also
9 be adjusted upward or downward.
10
11 (041) Step 100 Determine 90 Percent Point Of Secondary Filter- The actual
12 pressure drop across the secondary filter 34 is compared to the point where
13 the filter is completely filled and if the 90 percent point is reached then to Step
14 90. If not, to step 102.
15
16 (042) Step 102 Determine 80 Percent Point Of Secondary Filter- The actual
17 pressure drop across the secondary filter is compared to the point where the
18 filter is completely filled and if the 80 percent point is reached then to Step
19 106. If not, return to Step 86.
20
21 (042) Step 104 Display Alarm- A signal is generated causing a "80 PERCENT
22 FILTER READING" message to appear at the message screen 78 (Figure 4).
23
24 (043) Step 106 Send E-mail notification to all effected departments.
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26 (044) Step 108 Record Information- Return to Step 86 to continue monitoring.
27
28 (045) Referring to Figures1-6, when either the primary or secondary filters
29 need to be replaced, the blower 28 of course is turned off at panel 59. The
30 filter is replaced. The operator then restarts the blower 28 and presses the
31 screen at the "Detail and New Filter" button on the screen in Figure 5. This

1 brings up the screen illustrated in Figure 6. This screen includes a time history
2 section 112, where the actions taken by operators are recorded. A comments
3 section 114 where the operator can enter actions taken, etc. There is also a
4 spray booth not working light 116 and an initiated by space 117 and date
5 space 119. In addition there is a spray booth not working acknowledgment
6 button 120. Additionally date and time windows 121 and 122 indicated the day
7 and time. There is also a return to main menu button 124, which returns the
8 operator back to the screen in Figure 5. Thus a record of the spray booth
9 down time is maintained.

10
11 (046) Of most importance in the screen in Figure 6 are the filter change
12 control panels 126A and 126B. The control panel 126A includes a dial gauge
13 127, and digital gauge 128. A press to request filter change button 129, with
14 date and time windows 130 and 131 is also provided. Thus maintenance
15 personnel will be contacted to replace the filter. However, in some cases the
16 filter will already have been change. Assuming that the new filter is installed
17 the press to reset new filter button 132 is pressed and date and time windows
18 134 and 135 will automatically record the time and date. This will
19 automatically reset the gauges 71 and 72 in the screen in Figure 5. The
20 Control panel 126B operates in a similar manner and thus will not be further
21 discussed.

22
23 (047) When the operator presses button 132 press to reset filter, the program
24 as illustrated in Figure 7 will automatically add the allowable pressure drop
25 increase for the filter to the initial reading. This then becomes the starting
26 point for the primary or secondary filter digital read out gages 70 and 74 and
27 gages 72 and 76, as the case may be shown in Figure 5. Thus referring to
28 Figure 7 the steps are as follows:

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30 (048) Step 138 Install new filter- This requires that the old filters be removed
31 and replaced with new ones.

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(049) Step 139 Determine Initial Pressure Drop- The blower 28 is turned on and readings are recorded.

(050) Step 140 Add Allowable Pressure Drop Increase- This is the amount of pressure drop increase for the filter before it is considered ineffective.

(051) Step 141 Adjust Gage Readings- The Initial pressure Drop and Allowable Pressure Drop Increase are added together to provide a Total Pressure Drop. This value is then used in determine the 80 percent and 90 percent values.

(052) Thus it can be seen that the monitoring system compensates for the variation in initial pressure drop across the filter, increasing the useful filter life, provides a warning if an unusual pressure drop change occurs. Finally, only the spray gun is turned off, when filter limits have been reached and the blower will continue to operate insuring that and remaining paint particles or vapors are collected.

(053) While the invention has been described with reference to a particular embodiment, it should be understood that the embodiment is merely illustrative, as there are numerous variations and modifications, which may be made by those skilled in the art. Thus, the invention is to be construed as being limited only by the spirit and scope of the appended claims.

INDUSTRIAL APPLICABILITY

(054) The invention has applicability to the paint and coating application industry.